Studies on the *Mytilus edulis* Community in Alamitos Bay, California: II. Population Variations and Discussion of the Associated Organisms

BY

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(3 Text figures)

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INTRODUCTION

In a previous paper the author (1964) described the development and temporary destruction of a *Mytilus edulis* Linnaeus, 1758, community on boat floats in the newly developed marina in Alamitos Bay. The primary consideration was to determine whether or not succession occurred on the floats. The other principal organisms were discussed in connection with the development of the community. These included the green alga *Ulva lobata* (Kützing, 1849) Setchell & Gardner, the polychaete *Hydroides norvegica* (Gunnerus, 1768), the ectoproct *Bugula neritina* (Linnaeus, 1758), and the tunicates *Ciona intestinalis* (Linnaeus, 1767) and *Styela plicata* (Lesueur, 1823). The rôle of *M. edulis* and other large species in the fouling community has received a considerable amount of attention (Anonymous, U. S. Navy Report, 1952), but, with one exception (Newcombe, 1935) known to the author, the other members of the association have not been studied. Newcombe (*l. c.*) described the general seasonal aspects of the intertidal *M. edulis* community in New Brunswick, Canada. The principal and associated species were listed according to their relationship in the community.

All organisms were identified, in so far as was possible, and counted in connection with the development of the *Mytilus edulis* community in Alamitos Bay. In the analyses of these data variations were noted in the occurrence of the associated organisms. The discussion of these data constitute the basis of this report. Since the seasonal occurrence of the principal organisms was discussed previously, they will be mentioned only briefly herein.

ACKNOWLEDGMENTS

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MATERIAL AND METHODS

The methods of collection and the description of the boat floats were given in the previous paper. The collections were sorted and identified. Representative specimens of some of the groups were sent to specialists (named above) for identification; these specimens served as a reference collection for subsequent identification by the author.

DATA

Number of Species: The relationship between the number of species and water temperature has been summarized in Figure 1. A definite seasonal occurrence is noted in the number of species in the *Mytilus edulis* community. Peaks in the number of species were observed during August and September, 1960 to 1962, when the water temperature was highest. Conversely, the minimal periods in the number of species was during the winter months when the water temperature was lowest. The number of species collected averaged 11 when the water temperature was 13° C, 23 species at 16 to 18° C, and 28 species at 20 to 21° C.

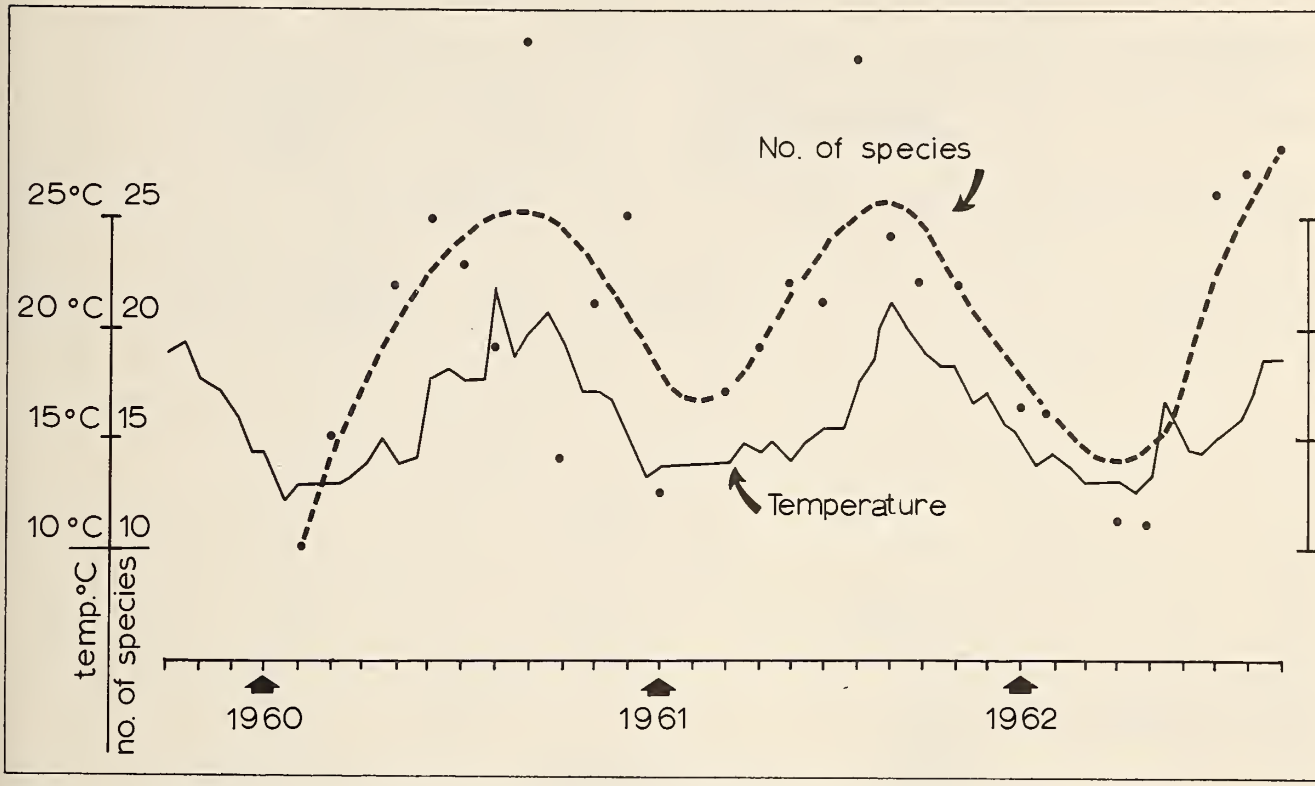

Figure 1: Seasonal Changes in the Number of Associated Species in the *Mytilus edulis* Community. The graph shows the relationship between the number of associated species of the *Mytilus edulis* community and water temperature in Alamitos Bay Marina.

The same seasonal relationship exists as above if we consider the relationship of the biomass of the associated organisms, excluding the weight of *Mytilus edulis*. The weight of the associated organisms averaged only 50 grams during the months of January through March, but reached a maximum of 260 grams during the months of July through September each year. The biomass of the *M. edulis* fluctuated little after establishment of the community.

Algae. Five species of algae were taken from the floats during the 2.7 years of collecting. A surge of algal growth was noted in March with a peak in biomass in June each year. *Ulva lobata* was the dominant alga and second to *M. edulis* in biomass. The spring and fall peaks in occurrence of *U. lobata* were discussed previously. The other species of algae collected included the brown algae *Ectocarpus confervoides* forma *parvus* (Saunders, 1898) Setchell & Gardner and *Leathesia difformis* (Linnaeus, 1755) Areschoug and the reds *Antithamnion ? secundatum* Gardner, 1927, and *Polysiphonia pacifica* Hollenberg, 1942. *Ectocarpus* cf. *parvus* was present, with one exception, only during the months of January through April, *Polysiphonia pacifica* was present during March through September.

Polychaetes. A total of 22 different species of polychaetes was collected during the 2.7 years of study. As a group they showed a definite seasonal occurrence with a peak in summer and a low during the winter months. Only four species were collected frequently; the occurrence and number of specimens taken have been summarized in Figure 2. *Halosydna johnsoni* (Darboux, 1899) is the only free-moving species of the four. It appeared in the *Mytilus edulis* community during the early spring months in each of the three years and was rarely taken during the winter months. The relationship of *Hydroides norvegica* to water temperature and seasonal occurrence has been discussed previously (Reish, 1961). *Platynereis bicanaliculata* (Baird, 1863) constructed mucoid tubes especially on the thalli of *Ulva lobata*. The occurrence of *P. bicanaliculata* was sporadic, but the majority of the specimens was taken during the spring months. *Polydora ligni* Webster, 1879,

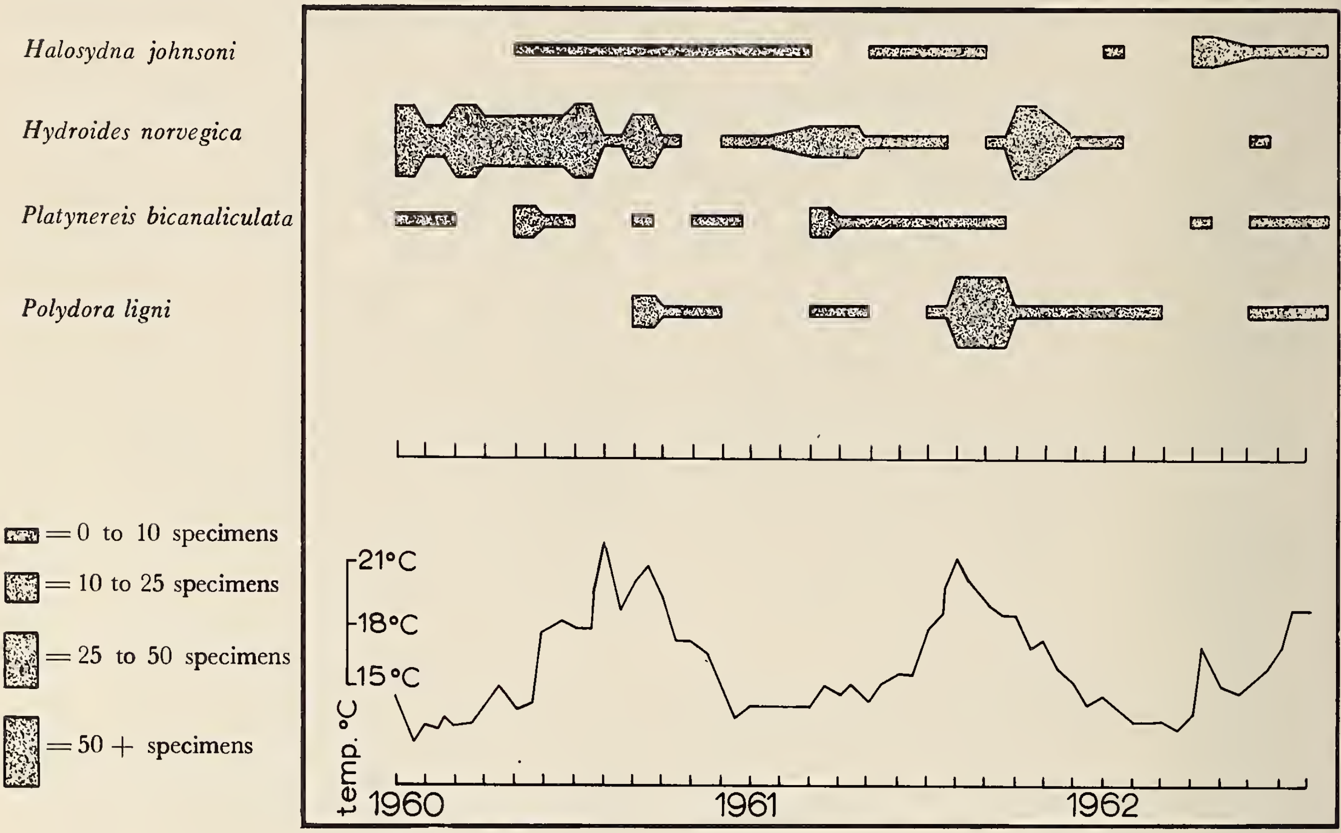

Figure 2: Seasonal Changes in the Polychaete Population associated with the *Mytilus edulis* Community. Diagrammatic representation of the relationship between the number of specimens of the principal species of polychaetous annelids and the water temperature.

built mud tubes on the thalli of *U. lobata* and among *M. edulis.* The majority of the specimens of *Polydora ligni* was taken during the summer months when the water temperature was highest. The other specimens of polychaetes collected included: *Armandia bioculata* Hartman, 1938, *Capitella capitata* (Fabricius, 1780), *Dorvillea articulata* (Hartman, 1938), *Eupomatus* sp., *Neanthes caudata* (delle Chiaje, 1828), *Naineris dendritica* (Kinberg, 1867), *Nereis grubei* (Kinberg, 1866), *N. latescens* Chamberlin, 1919, *Ophiodromus pugettensis* (Johnson, 1901), *Paleonotus bellis* (Johnson, 1897), *Pista alata* Moore, 1909, *Polyophthalmus pictus* (Dujardin, 1839), sabellid, *Spirabranchus spinosus* Moore, 1923, spirorbinid, terebellid, and *Typosyllis* sp.

Amphipoda. Amphipods constituted the dominant group of animals in terms of numbers of specimens (Figure 3). Peaks occurred each summer with 1690, 17450, and 5121 specimens in 1960, 1961, and 1962, respectively. This is in striking contrast to minima of 3, 6, and 71 specimens during the winter months for each of these three years. Nine species of amphipods were taken from the floats during the period of study; the seasonal occurrence and abundance of the five dominant ones are summarized in Figure 3. The correlation between the warmer water temperature and the abundance of these amphipods, and especially *Elasmopus rapax* Costa, 1853, can be seen in Figure 3. *Corophium acherusicum* (Costa, 1857) and *Jassa falcata* (Montagu, 1808) constructed sticky parchment tubes to which mud particles adhere. The tubes occurred on the thalli of *Ulva lobata* and between and on specimens of *Mytilus edulis. Ampithoe plumulosa* Shoemaker, 1938, *Caprella californica* Stimpson 1857, and *E. rapax* moved freely about the community. The other species of amphipods taken were *Caprella equilibra* Say, 1818, *Ericthonius brasiliensis* (Dana, 1853), *Leucothoides pacifica* Barnard, 1955, and *Pontogeneia minuta* Chevreux, 1908. Barnard (1958) found heavy settlement of amphipods on 16-week test blocks collected August 17, 1951, in Los Angeles

Harbor. Species in common with the present study included *C. acherusicum, J. falcata,* and *E. brasiliensis.*

Mollusca. Eleven different species of mollusks were present on the floats including species of gastropods, pelecypods, and a chiton. *Mytilus edulis* was the dominant member of the community; its abundance has been discussed earlier. As a group, but excluding *M. edulis,* the seasonal occurrence of the mollusks is striking. They are present abundantly during the spring and summer months but nearly absent during the fall and winter months. Such a cycle is noted with the pelecypod *Hiatella arctica* (Linnaeus, 1771), and the gastropods *Acmaea limatula* Carpenter, 1864, and *Crepidula onyx* Sowerby, 1825. The other mollusks occasionally encountered included the pelecypods *Ostrea lurida* Carpenter, 1863, and *Leptopecten latiauratus* (Conrad, 1837); the gastropods *Acmaea scabra* (Gould, 1846), *Littorina planaxis* Philippi, 1847, *L. scutulata* Gould, 1849, and unidentified nudibranchs; and the chiton *Mopalia muscosa* (Gould, 1846).

Ectoprocta. Six species of ectoprocts were present during the study. A slight increase of species was noted during the course of the year with a peak occurring during the summer months; this was followed by a sharp decrease in the fall months. This was especially true for the most frequently encountered species, *Schizoporella unicornis* (Johnston, 1847). Other species included *Bugula californica* Robertson, 1905, *B. neritina* (Lin-

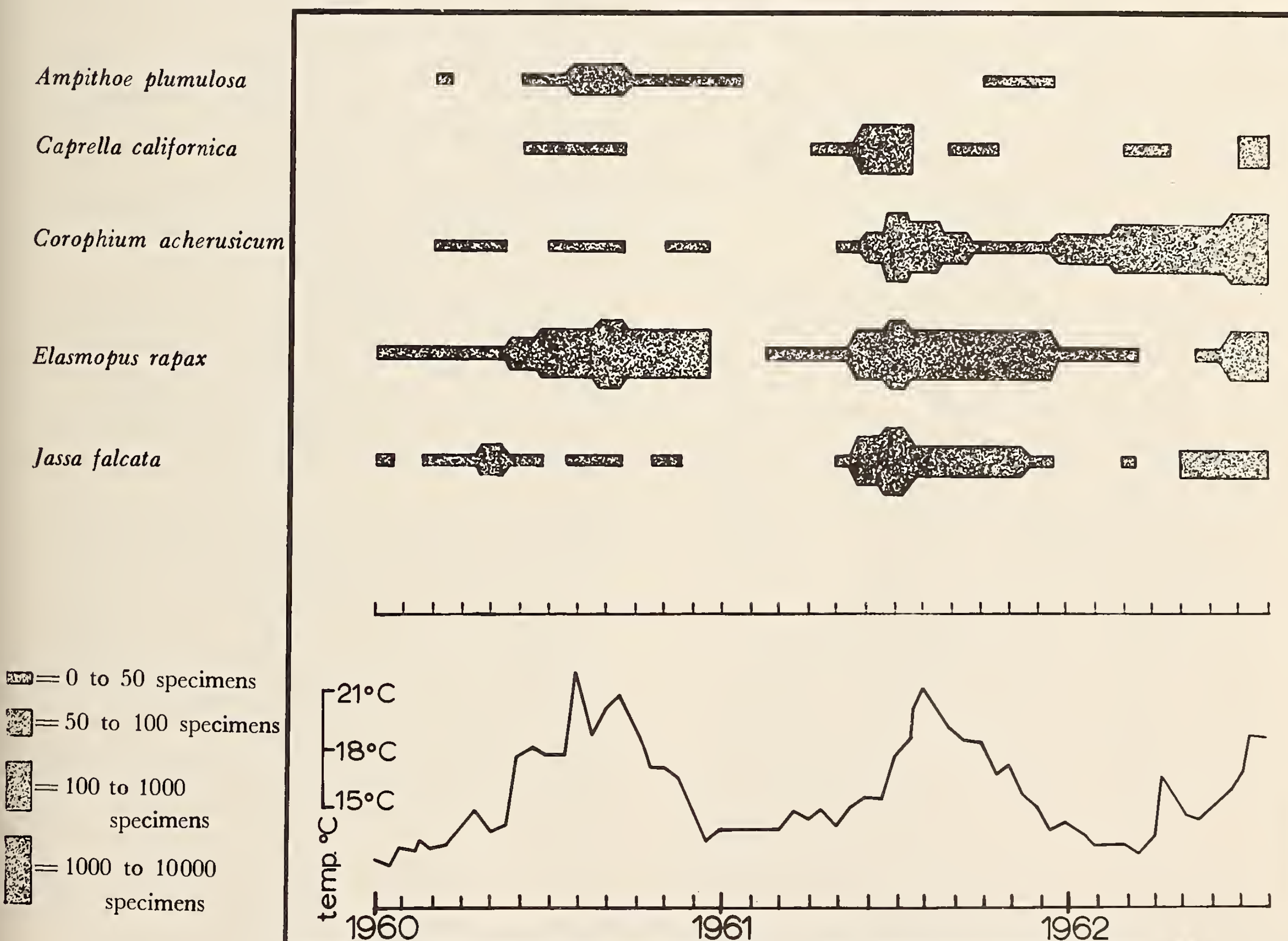

Figure 3: Seasonal Changes in the Amphipod Population Associated with the *Mytilus edulis* Community. Diagrammatic representation of the relationship between the number of specimens of the principal species of amphipods and the water temperature.

NAEUS, 1758), *Cryptosula pallasiana* (MOLL, 1803), *Holoporella brunnea* (HINCKS, 1884), and *Scrupocellaria bertholetti* (AUDOUIN, 1826).

Tunicata. Six species of tunicates exhibited definite seasonal differences with a peak in summer and a low in fall and winter. *Ciona intestinalis* was the most abundant one taken. While individual specimens can be seen generally more frequently during the summer, the larval settlement is earlier in the year when the water temperatures are lower. *Amaroucium californicum* RITTER & FORSYTH, 1917, *Botryllus* sp., *Diplosoma pizoni* RITTER & FORSYTH, 1917, and *Styela plicata* were limited to the months of May through September with only a few exceptions (13 per cent). *Styela montereyensis* (DALL, 1872) was present throughout the year.

The remaining species of animals, none present frequently and some only once, included two unidentified sponges, sea anemones, polyclad flatworms, nemerteans, barnacles (*Balanus amphitrite* DARWIN, 1854, *B. crenatus* BRUGUIÈRE, 1789, and *B. glandula* DARWIN, 1854), an isopod, a shrimp, the crab *Hemigrapsus oregonensis* (DANA, 1851), and one juvenile sea urchin, *Strongylocentrotus purpuratus* STIMPSON).

DISCUSSION

The relationship between the number of species and the water temperature is clearly evident in Figure 1. The greater number of associated species was found during the summer months and the lesser number was collected during the winter months for three successive years. While comparative data are not available, it has been demonstrated throughout the world that the heavier attachments of fouling organisms take place in the warmer water (summarized in ANONYMOUS, U. S. Navy report, 1952). Presumably, the smaller associated animals would be more abundant at this time.

The reproduction, development, life history, and length of life are unknown for the majority of the organisms encountered. *Mytilus edulis* is undoubtedly the longest living member of the community. Some species of animals, for example *Ciona intestinalis,* have one life cycle a year in which the larvae settle in spring, grow in summer, and die in fall. Other organisms exhibiting this type of cycle probably include most of the other species of tunicates and the ectoprocts. Other species, and this is especially the case with amphipods, have many cycles during the spring and summer months. In this manner large populations are built up and undoubtedly the same female broods several successive generations. The population diminishes with the drop in water temperature in the fall. Undoubtedly a few larvae of a species, which are typical inhabitants of some other ecological niche, may settle in the *Mytilus edulis* community. This is evident with the polychaetes; the majority of the polychaetes collected is more commonly encountered in the benthos.

The breeding period and subsequent settling period has been divided into four categories depending upon the seasonal aspects of attachment (ANONYMOUS, U. S.Navy report, 1952). These categories may be modified slightly and the more frequently encountered species grouped according to: (1) occurrence throughout the year without fluctuations: *Holoporella brunnea, Scrupocellaria bertholetti,* and *Styela montereyensis;* (2) occurrence throughout the year but with a definite spring or summer peak: *Halosydna johnsoni, Hydroides norvegica, Platynereis bicanaliculata, Polydora ligni, Elasmopus rapax, Corophium acherusicum, Schizoporella unicornis,* and *Styela plicata;* (3) occurrence limited to a definite period of the year which is usually either spring or summer: *Polysiphonia pacifica, Ectocarpus* cf. *parvus, Ampithoe plumulosa, Jassa falcata, Pontogenia minuta, Hiatella arctica, Acmaea limatula, Crepidula onyx, Bugula californica, B. neritina, Cryptosula pallasiana, Amaroucium californicum, Ciona intestinalis, Botryllus* sp., and *Diplosoma pizoni;* and (4) peaks occurring in the spring and fall: *Ulva lobata* and *Polyophthalmus pictus.*

SUMMARY

1. A seasonal quantitative study was made for 2.7 years of the associated species of the *Mytilus edulis* community of the boat floats in Alamitos Bay Marina, California.
2. The principal associated groups include species of polychaetes, amphipods, mollusks, ectoprocts, and tunicates.
3. A direct relationship between the number of species and water temperature was observed; the warmer the water, the greater the diversity of the organisms.
4. The occurrence of the principal species was arranged according to the following categories: (1) occurrence throughout the year without fluctuations (3 species) (2) occurrence throughout the year but with a definite spring or summer peak (8 species), (3) occurrence limited to a definite period which was usually spring or summer (15 species), and (4) peaks occurring in the spring and fall (2 species).

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A Note on the Synonymy of *Tellina subtrigona* Sowerby, 1866
(Mollusca: Bivalvia)

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(Plate 27, Figures 1, 1 a)

In 1866, Sowerby first described *Tellina subtrigona* in volume 17 of Reeve's Conchologia Iconica; the type figure is figure 9, plate 3 of *Tellina*; no locality datum was given. Later, in 1868, in the same monograph, he again described a species with the name *Tellina subtrigona* (plate 44, figure 259). After he discovered his error, he corrected the latter to *Tellina subangulata* in the index; *T. subangulata* is synonymous with the Indo-Pacific species, *T. juvenilis* Hanley.

Recently, Keen (1958) has suggested the probable identity of *Tellina erythronotus* Pilsbry & Lowe with *T. subtrigona* Sowerby, 1866. Hertlein & Strong (1949) in their remarks under *T. erythronotus*, did not mention *T. subtrigona*, but have listed the names of a number of species which are synonymous with or closely related to *T. subtrigona*. In 1852, C. B. Adams described *T. puella* from the Pacific coast of Panama; this name was unfortunately preoccupied by *T. puella* Hanley 1846. Salisbury (1934) recognized *T. puella* Adams as a junior homonym and renamed it *T. puellula*. Turner (1956) selected and figured the lectotype of *T. puella* Adams. Keen (1958) considered *T. puellula* as valid but mentioned that it was very close to *T. erythronotus*. Olsson (1961) recognized that *T. puella* Adams and its substitute name, *T. puellula* Salisbury, were synonymous with *T. erythronotus*.

Presently, we are able to include *Tellina subtrigona* Sowerby, 1866 in this synonymy, and this name will replace *T. erythronotus*. An examination of the type material has indicated the identity of the following: *Tellina subtrigona* Sowerby, 1866; *T. puella* C. B. Adams; *T. puellula* Salisbury; and *T. erythronotus* Pilsbry & Lowe. Plate 27, figures 1 and 1 a illustrate the holotype of *T. subtrigona* Sowerby, 1866 and the following is the synonymy of the species:

Tellina subtrigona Sowerby, 1866 [in] Reeve, Conchologia Iconica, vol. 17, *Tellina*, pl. 3, fig. 9 (type locality unknown; holotype, BMNH, no catalog number; 22 mm in length and 13 mm in height), *non* Sowerby, 1868.

Tellina puella C. B. Adams, 1852, Ann. and Lyceum Nat. Hist. New York, 5: 507 and 546 (reprint pagination, 283 and 322); Turner, 1956, Occ. Pap. Moll., Harvard University, 2 (20): 77, pl. 19, figs. 13, 14 (type locality, Panama [Pacific coast]; lectotype, selected by Turner, 1956, MCZ 186305; 22 mm in length, 13 mm in height and 7 mm in diameter), *non* Hanley, 1846.

Tellina erythronotus Pilsbry & Lowe, 1932, Proc. Acad. Nat. Sci. Philadelphia, 84: 94, pl. 12, fig. 7 (type locality, Panama, east of the city; holotype, ANSP 115010; 19.5 mm in length, 10.7 mm in height, and 5 mm in diameter).

Tellina puellula Salisbury, 1934, Proc. Mal. Soc. London, 21 (2): 86 (new name for *T. puella* C. B. Adams, 1852, *non* Hanley, 1846).

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